HOSPITAL AND TRAINING SCHOOL ADMINISTRATION

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THE HYGIENE OF VENTILATION

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THE importance of the problem of ventilation is not to be questioned. It is well known that overcrowding, beyond a certain point, is fatal, as was illustrated by the notorious Black Hole of Calcutta and by the underground prison at Austerlitz. Conversely, the fresh air treatment of tuberculosis and other diseases is one of the fundamentals of medical and hygienic practice.[1] It would at first glance appear to be simply a question of adequately replacing the vitiated air within by a never ending stream of fresh air from the inexhaustible supply without by natural or artificial means, but this, as we know, is often extremely difficult under present conditions of home and business life in cities.

The latest stipulations made for adequate ventilation are that the quantity of air and its physical condition must be considered in order that the human machine may operate at the highest level of health and efficiency. In fact a satisfactory system of ventilation must comply with many requirements before it is accepted: 1, It must bring pure air from without in order to dilute and remove the products of respiration, as well as other sources of vitiation; 2, It must maintain the air within the room at a proper temperature and humidity and, further, must keep the air of the room in gentle and continuous motion; 3, It must remove the gases, odors, bacteria, dust and other substances that contaminate the air of inclosed spaces; 4, It must dilute and remove the impurities produced by the burning of gas, candles, lamps, and other sources.[2]

There has been a gradual development from the former popular theory,—that the noxious effects of crowded spaces were from the chemical vitiation of the air with the consequent diminution of oxygen and increase of carbon dioxide, to the present idea,—that these harmful effects of bad ventilation are closely correlated with high temperature, and humidity of the air, aided by its lack of motion. This present point of view has been definitely proven true by Weisman and by the experiments of the New York State Ventilation

[1] Winslow, *Science*, April 30, 1915.
[2] Rosenau, Preventive Medicine and Hygiene.

Commission [3] made possible by the generous gift of Mrs. Elizabeth Milbank Anderson through the New York Association for Improving the Condition of the Poor, as one of the activities of its department of Social Welfare. Experiments were carried out by this Commission in two rooms in the College of the City of New York, which were equipped so that atmospheric conditions in one room could be very closely controlled by an apparatus in the other. The students of the college were used as subjects for these experiments. They noted that the thermometer was the first essential in estimating the success of ventilation. Many practical developments by heating and ventilating engineers have confirmed this. It may be safely stated that there is no toxic, organic substance in expired air that can account for the harmful effects observed.

Over thirty years ago the first champion of this new conception was Hermans, who suggested that poor ventilation is due to the physical, rather than the chemical condition of the air. He was supported in this view by Haldane, Flugge, Hill, Benedict and others, but not until Haldane published his work in the *Journal of Hygiene,* 1905, did this new idea come to be generally considered.

The general problem of poor ventilation is inseparably linked with that of respiration, as was noted in all the original investigations. It has been proven that increased activity means an increase in oxygen consumption, which in its turn means heat production. It follows from this, since man is a relatively homoiothermal organism, that there must be an approximately proportionate heat elimination. Experiments amply prove that muscular exercise increases in general the output of metabolic products and of heat.

The New York Ventilating Commission in its extensive experiments showed that the increased humidity and temperature of the air deranged the vaso-motor system, lowering the Crampton index of vasotone so that there was interference with a ready adaptation on the part of the vascular mechanism to changes of position or to reflex stimulation. They also observed that increased surrounding temperature increased the heart rate, the respiration rate, and consequently decreased the respiratory volume, inducing vaso-dilation of the blood vessels of the skin, rendering the brain, spinal cord and various tissues correspondingly anemic. Putting the same fact into the words of Reed,[4] "It is suggested that, in some way, poor conditions of ventilation produce effects that are manifested in the physiologic machine in much the same way as the effects of fatigue are manifested."

[3] Herzotein, *Survey,* February 20, 1915.
[4] Reed, *American Journal of Public Health,* September, 1919.

The combined work of numerous investigators [5] has established the fact that metabolism is proportioned to body surface area. Every twenty-four hours nearly two quarts of water pass from the body as insensible perspiration as well as in vapor from exhaled air of the lungs. The heat which vaporizes the moisture, rendering it "insensible," is taken from the warm body and from the air immediately surrounding the body, meaning probably a daily loss of nearly 500 calories. And so we see that in life humidity and temperature are coexistent factors and therefore must be considered together. From eighty-five to ninety per cent of all heat loss takes place through the skin by evaporation or perspiration, as is commonly discussed in physics under radiation, convection, and conduction. Experiments show that an ordinary adult will produce and must be relieved of sufficient heat in the course of an hour to raise the temperature of 1,000 cubic feet of air, 15 to 20 degrees. If this cooling evaporation of perspiration from the surface of the body is diminished by overheated and humid air, and if the hot, humid envelope next the skin does not give place to a cooler, dryer layer with its relieving quality [6] there results a feeling of weariness, indifference and apathy toward any form of labor.[7]

To maintain a constant body temperature, metabolism must be cut down, and this is done reflexly through the heat regulating center. Health and life itself depend upon a uniform temperature of the blood. A "comfort zone" for indoor temperature has been defined by the Chicago Commission of Ventilation: namely, a temperature somewhere between 13 to 21 degrees C., or 55 to 70 degrees F., and a humidity of 30 to 55 per cent, a much lower relative humidity than that found out of doors.

Although it is true that, as carbon dioxide increases in amount in occupied rooms the temperature and humidity also increase, nevertheless carbon dioxide does not accumulate in a room in direct ratio with either heat or humidity and cannot, therefore, be used as a determining factor in ventilation.[8]

For satisfactory ventilation, not only the physical condition of the air must be considered, but also a generous supply of fresh air is found necessary in order to keep the chemical composition within reasonably normal limits. Attention, however, should be directed to the source of this fresh air. It is unsatisfactory if it is smoky, dusty, bacteria laden, or if contaminated with gases or odors from cellars or immediate surroundings. It is a foolish empiricism which maintains

[5] Hubbard, *Architectural Record*, January, 1917.
[6] Kober and Hanson, Diseases of Occupation.
[7] See *American Journal of Public Health*, November, 1917.
[8] Broadhurst, Home and Community Hygiene.

that outdoor air, as nature makes it, is necessarily the final word in air conditioning. It is known, in general, that dry air is a tonic and stimulating, as also is cold air; that warm air is depressing, and moist air is even more so. It is the task of applied science to take the best elements in a natural environment without the bad.[1] In fact, the art of ventilation consists in adapting indoor conditions to indoor life. As much forethought and scientific study should be put into this system as is always put into the water, gas, electric and plumbing systems when building a house, office building or factory.

Removal and dispersion of bad air and the introduction of fresh air are accomplished either by natural or artificial means. Window ventilation has been put forward as a panacea for all ventilation ills, but how little is scientifically known of its worth or its difficulties. Coincidentally, splendid advance has been made in the working out of the mechanical problems of ventilation.

In estimating air needs, most people still accept 2,000 cubic feet per hour as the average need for each individual, but it is now realized that the upper layer of air is little affected by the fresh air below, hence this leads some authorities to emphasize the square feet of floor space. These later requirements range from 10 to 50 square feet per person, varying with the cubic feet of air space also obtainable for each. It is not alone the air space, but also the shape of the room that influences ventilation. Ordinarily, 12 feet is high enough for the ceilings of school rooms, museums, and hospitals, and 9 feet for the rooms of private dwellings.

By the use of thermostatic devices, accurate control of the degree of humidity and heat can be obtained. The best results in artificial humidification have been through the medium of the air washer. While the primary duty of the air washer was to remove dust and soot from city air, its field was soon extended to air moistening and cooling through devices for controlling the temperature, and also extended to the removal of bacteria, molds, epithelial scales, particles of various descriptions, as well as odors and some gases, but not carbon dioxide. Washing is the best way to purify the air, as it imitates nature's process during a rain shower. In 1913-1914, the Ventilating Committee of Springfield showed satisfactorily that there was no difference between washed recirculated air and outdoor air similarly treated, as far as bodily comfort was concerned.[9]

Whether ventilated by natural or mechanical means, proper inlets for the fresh air, and outlets for the vitiated air must be provided. Perhaps the best arrangement is to have the inlet above and the outlet below, both on the same side of an inner wall, with attention

[9] Kimball, *Science*, April 30, 1915.

paid to the source of the fresh air inlet. Crowded buildings and dusty city streets, smoke and spent gases from automobiles, render a clean, secure air impossible without resorting to artificial purification. This fact points out the necessity for external ventilation in general,—a problem for the Public Health Department.

Artificial ventilation is expensive to install and maintain, but still it is effective in all kinds of weather, and requires less space for air ducts than does natural ventilation. A combination of the plenum and vacuum systems is the best method. The initial provisions or methods of artificial ventilation are: (1) Suitable inlets and outlets; (2) extraction by heat or creation of decided difference; (3) propulsion and aspiration. Any of the ordinary registers in which the air passes through the walls by means of a perforated iron plate, and is directed downward by a valved plate with side checks, will prove of service.

Health is the one great asset of the individual, and consequently of the nation, and when the relation of physical comfort and efficiency is firmly established we may expect to find all civic and commercial institutions fitted with cooling plants for summer as well as heating plants for winter. The efficient heating system is less than ninety years old, and the refrigerating system is already perfected, hence we may confidently expect some relief from summer heat within the next generation.

Our modern air, then, in schools, offices, public buildings and homes ought to be free from dust and odor and ought to have the proper physical characteristics and be supplied in sufficiently large amounts, thus playing a distinct and highly important part in the general trend of things toward an ever higher efficiency.

MISS MAXWELL WRITES FROM FRANCE:

"A memorial to the late Jane A, Delano has been established at Diben-Plougasnou, one of the rocky points on the coast of Brittany.

"A fund for the support of the work has been given by Miss Randolph of Baltimore, a school for the children has been opened, social work in the form of classes for girls, and instruction to mothers is carried on by the sisters. A nurse visits the sick, and cares for them in their homes. No higher tribute could be paid the memory of Miss Delano, who gave so much of her life to the cause of nursing."